GEOCHEMICAL GAS SAMPLING OF THE MEDINA SANDSTONE COLLINS, NEW YORK PROSPECT

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Final Report

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Abstract and Key Words

A geochemical (soil gas) survey was conducted over a seven square mile area in southern Erie County, New York. The purpose of the study was to ascertain whether a relatively inexpensive geochemical survey could be utilized to delineate commercial Medina Formation natural gas reserves. The survey was completed in late 1998 and subsequent results delineated two apparent trends. A well was drilled in June 1999 on a geochemical anomaly. This well (Hofmann Unit #1) has performed better than surrounding production since commencing production in September 1999. More recently, two new wells drilled in February 2000 also seem to help support the geochemical survey although the results of these wells are still preliminary. Thus, initial indications are that above average Medina reservoirs can be delineated with soil gas surveys.

Key Words

Geochemical

Survey

Medina

Formation

Acknowledgements

The author would like to acknowledge the work performed by the primary subcontractor Mr. Rick Reeve. Rick was responsible for the grid layout, sampling, interpretation of lab results and presentation of the findings at the New York State Energy Research and Development Authority's summer technical seminar held in Clymer, New York in July 1999. It is from Rick's presentation that I am borrowing (with permission) much of this report. I would also like to thank Jim Fasnet of Gallagher Labs in Denver for his prompt review of our samples, and interpretive assistance including a trip to Clymer in July to assist the explanation of the findings. Lastly, I would like to thank Dr. John P. Martin and the New York State Energy Research and Development Authority for their involvement and support. Without it, this survey may not have occurred and our development of this project may have been hampered.

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INTRODUCTION

U.S. Energy Development Corporation assembled a block of acreage in Collins and Concord Townships in Erie County, New York for the purpose of drilling for the Medina Formation. **(See Figure 1.)** The project contains over 4,000 acres located between the Collins Storage to the southwest and the Concord Medina pool to the east.

Figure 1. General Map – Collins Prospect

A geological study of the area conducted by U.S. Energy showed two old wells drilled in the early 1990's encountered the Medina Formation. These wells had no significant natural shows and were plugged. U.S. Energy used this data to extrapolate a northeast to southwest trend across the prospect. A subsequent leasing effort ensued.

U.S. Energy was looking for a cost-effective method of evaluating the acreage block without resorting to random drilling. One method U.S. Energy was aware of from exploratory efforts in Ohio was the use of soil gas geochemistry.

The sampling was completed in November 1998. Processing and interpretation occurred throughout the winter of 1998-1999. The first Medina well (Hofmann Unit #1) based on the geochemistry and was drilled in June 1999. The well commenced production in September 1999 into National Fuel Gas Distribution and has produced since then.

A presentation of the survey and results was made by the primary subcontractor, Mr. Rick Reeve, at the NYSERDA technical seminar held in Clymer in July, 1999.

U.S. Energy has been encouraged with the initial production and has drilled additional wells in the prospect area.

THEORY

Thousands of soil gas surveys throughout the world have proven that nearly all reservoirs at depth leak to some degree. This leakage may be occurring in very minute quantities, but it is continuous and eventually reaches the surface. The leaking hydrocarbons are travelling in different directions but a large portion of it is leaking in a vertical direction.

In order to provide scientific control on the use of geochemistry, it was determined that a survey over a portion of a similar field should be conducted. The analog field should be of a comparable depth, virgin reservoir conditions and production from the same horizons. Although there are many Medina Formation pools at a comparable depth, most are near depletion. This lead U.S. Energy to use the nearby Collins Storage Field, with the permission of National Fuel Gas Supply.

The storage samples were acquired in November when the field was full and at original reservoir pressures. Although the current gas in the Collins storage pool is not indigenous to the Medina Formation, it was at original rock pressures for this depth, which supports the use of these samples as concentration analogs as opposed to hydrocarbon compositional analogs. Soil gas concentrations in the soils near the surface are directly related to the rock pressure of the hydrocarbons at depth. Sampling of the Collins Storage pool with its rock pressures similar to original rock pressures in the Medina in this area provides useful information about the anticipated surface concentrations. These concentrations would be greater than the signature which expected from the shallower sandstones and shales in the area, which are known to contain free gas.

SAMPLING METHODOLOGY

Each sample site was surveyed prior to acquisition. Surveying involved a distance measurer used in conjunction with a compass and topographic map of the area. Areas of heavy brush or inaccessible topography were surveyed with 100 foot tape and compass. Sample acquisition for the 301 total samples collected took 9 days, which included bothe the prospect area and the control survey over the Collins Storage Field.

Soil gas samples were acquired using a two-inch diameter, four feet long auger. At each sample site, the hole is augured to a depth of three feet. Upon reaching this depth, the hole is carefully cleaned out by running the auger in place until no more dirt comes up the auger flights. The hole is then deepened an additional 6 to 12 inches and the samples taken. A handful of the soil is then placed into a ½ pint mason jar which has previously been half filled with regular tap water. Soil is added until there is about 1 inch of empty headspace left at the top of the jar. A lid with a ¼ inch hole drilled through the center is placed over the jar, the hole is covered by a rubber septum about the size of a nickel and then another drilled lid is placed over the rubber septum. The ring of the jar is then screwed on, firmly holding the lids in place creating an air tight seal. The samples were sent to the Gallagher Research & Development Labs in Denver for analysis. Gallagher Research performs lab analysis for soil gas surveys.

TESTING

Prior to withdrawing any headspace gas for analysis, the samples were gently shaken and placed in a warm water bath. This has the effect of gently liberating any free soil gas and soil gas loosely adsorbed in the pores of the soil. Measurements are made of this headspace gas by inserting a chromatographic needle through the rubber septum and extracting a set volume of headspace gas. The gas is injected into a gas chromatograph which analyzes the type and concentrations of hydrocarbon gases in the headspace. The chromatograph analyses for methane, ethane, ethene, propane, propene, isobutane, butane, isopentane, and pentane.

In addition to measuring for direct hydrocarbons, the Eh, pH, and conductivity of each sample is also measured. Each of these measurements can provide an additional confirmation of actively seeping hydrocarbons. Leaking hydrocarbons set up chemical conditions within the soil over productive areas which are distinctly different from conditions over nearby barren areas. Actively seeping reservoirs have a continuous flux of hydrocarbons making their way to the surface. Hydrocarbon-consuming bacteria in the soil feed on the hydrocarbons and leave behind the byproduct of carbon dioxide. This leads to the development of a reducing zone characterized by a low Eh environment within the geochemical chimney directly over the seepage. Eh is measured in millivolts and tends to be very low or even negative in the areas of greatest seepage.

Measurements are also made for pH of each sample. The pH is a measurement of the soil acidity or alkalinity. The carbon dioxide left behind after bacterial degradation of the soil hydrocarbons leads to the development of different carbonate minerals within the geochemical chimney. This in turn leads to a slightly elevated pH (greater soil acidity) over the chimney. Along the edges of the hydrocarbon seepage there are higher pH's leading to a halo type signature of higher pH's surrounding lower pH's. Background values tend to be lower than areas with actively seeping hydrocarbons.

The conductivity of each sample is measured. Soil conductivity measurements give the total concentration of ions in each sample. The higher pH environment along the edges of the seepage leads to the accumulation of different mineral salts along these edges, which in turn leads to increased conductivity within the edge areas. Again this leads to a halo type of signature as opposed to the total hydrocarbon concentrations.

The stacking of these various parameters leads to greater confidence in the predictions made concerning a hydrocarbon anomaly. Where these various parameters agree with one another, i.e. high hydrocarbons, low Eh, elevated pH and a conductivity halo around an area, the prediction for commercial production is generally stronger.

STUDY DESIGN

After examination of the lease block, it was decided to design a grid involving samples taken 700 feet apart in an east-west direction with sample lines spaced 1000 feet apart in a north-south direction. This coarse grid spacing was designed to identify large reservoirs (100+ acres) and is related to the overall size of the prospect area (7.5 square miles). This project was originally designed to include 300 samples. Small areas of no permits and some swampy areas reduced the number of samples acquired in this survey to 277. **(See Figure 2.)**

Figure 2. Soil Sample Locations

As previously mentioned, the Collins Storage Field was utilized as a control. National Fuel Gas Supply allowed the acquisition of a series of samples in a north-south direction over the storage field. Twenty four samples were taken in a north to south line from the southern boundary in the Zoar Valley State Park north to a point about one mile north of the storage field. This area is about two miles southwest of the main survey area.

THE COLLINS STORAGE FIELD – GEOCHEMICAL SURVEY RESULTS

Figure 3. Sample Locations – Collins Storage

As previously discussed, in order to understand the results obtained in the survey over U.S. Energy's project area, test data was acquired over National Fuel Gas' Collins Storage Field. The next figure (**Figure 3.**) shows the location of the storage field samples. A total of 24 samples were collected along two north-south roads. Samples were taken 500 feet apart. Approximate limits of the storage field are shown however the true extent of the actual field is in between samples 5 and 15. As stated previously, the overall compositional data generated from the 24 samples probably will not be exactly the same as the samples in the main survey as the gas is not indigenous to the Medina Formation. It was anticipated that the overall hydrocarbon concentrations would be similar, as the overall pressures of the two reservoirs are similar. Also, the Eh, pH and conductivity data should be comparable, as these parameters are dependent upon concentrations of hydrocarbons in the soil as opposed to compositional content.

Figure 4. Collins Storage – Methane Map.

Figure 4. is the methane map for the storage samples. The map is not gridded because of the straight-line nature of the data. Storage field limits are shown by the heavy black lines at sample 5 and 15 on the north end. The samples ranged from 17 ppm in the northern part of the line to a maximum of 7892 ppm in the center of the traverse at Sample #14. Sample 16 is also very high at 3346 ppm. It is possible that samples 14 and 16 are biogenic methane from vegetation decay as both were taken in areas of black, mucky soil. Propane for both samples was very low, tending to support this conclusion. Biogenic methane will not be accompanied by any of the other hydrocarbons as only methane is produced by this decay. Sample 10 was taken in the vicinity of the intersection of a gas gathering and a large gas transportation line and may indicate pipeline leakage in this area. The graph of the data is definitely skewed by the high methane concentrations of these three samples. Overall the methane map shows fairly high values from samples 1-15. This shows a correlation with the northern end of the storage field. On the south end of the traverse, we see wells adjacent to samples 5 and 6 which these are the southernmost wells in the storage field. Based on the continuation of the high methane soil concentrations, it is possible that there is a continuation of the storage gas to the south.

Figure 5. Collins Storage – Propane Map.

The propane map (**Figure 5.**) of the storage samples is probably a better indicator of the true extent of the storage field. Field limits are shown by the heavy black lines. The sample concentrations run from a low of 1 ppm on the northern end of the survey to a high of 82 ppm at sample 15. Sample 15 marks the northern edge of the storage field based on wells drilled in the area and the geochemical data. The mean of this propane data is 17 ppm. The mean of the survey samples taken over the U.S. Energy survey is similar at 16.5 ppm. Propane concentrations appear to match the storage field limits except in the southern extent where the higher concentrations extend to the survey limits.

Figure 6. Collins Storage – Eh Map.

The Eh for the storage field is shown on the next figure (**Figure 6.**). The dividing line between red and green areas is zero. The known storage limits are shown by the heavy black lines at samples 5 and 15. Over a possible reservoir there should be low or negative Eh's. Low Eh is an indication of reducing conditions which are expected over actively seeping hydrocarbons. The Eh over the storage field is red (negative). The only positive areas are from samples 4 – 6, 9, 18, and 21. This map shows the relationship for samples 19 through 24 which would not be expected to be negative, as they do not appear to be over seeping hydrocarbons. Samples 1 through 3 are very negative and this combined with the high hydrocarbons in this area may indicate an extension of the storage field gas to the south of the known limits.

Figure 7. Collins Storage – Ph Map.

The pH map **(Figure 7.)** is exhibiting a classic signature looked for with pH. The field limits are shown by the black lines. Lower pH's appear over the center of the field surrounded by higher pH's along the edges, forming a halo signature.

Figure 8. Collins Storage – Conductivity Map.

The conductivity map **(Figure 8.)** also shows the relationship expected over actively seeping hydrocarbons. Field limits are shown by the black lines. Lower conductivities over the heart of the storage field are surrounded by higher conductivities north and south of the field limits. Conductivity measurements are an indirect indicator of hydrocarbons with higher conductivities found in the area surrounding the geochemical chimney because of the formation of various salts and carbonates leading to greater conductivities in this higher pH regime.

Figure 9. Collins Storage – Stacked Parameters

In order to derive the stacked parameter map **(Figure 9.)** for the storage field, each of the individual parameters measured for in the survey, including the methane, propane, Eh, pH and conductivity are assigned threshold anomalous values. When a sample parameter is over the threshold limit, it is assigned a positive parameter. The individual parameters are summed for each sample to see how many parameters are over the threshold. A 5-parameter sample would mean that each of the individual parameters for a sample are over the threshold limits which would be an indication of probable commercial production.

The map for the storage field shows mostly 4 parameters stacking throughout the southern portion of the survey. Sample 15 at the northern end of the field has the only 5 stacked parameter value. North of sample 15 are a cluster of 0 to 2 parameter values, indicating a probable lack of commercial production. Samples 1 through 4 below the southern end of the field limits all have 4 stacked parameter values, indicating a possible southern extension of the field limits.

The samples through the storage field have provided a producing analog for comparison. From the individual parameters measured, the microseepage from the storage field does have a discernable geochemical signature at the surface. A map showing statistical similarities between the Collins Storage Field and U.S. Energy's prospect area was prepared and shows a good correlation between the two data sets. This map is discussed later on with (**Figure 16**).

COLLINS PROSPECT GEOCHEMICAL SURVEY RESULTS

Figure 10. Collins Prospect – Methane Maps.

Figure 10 shows the methane concentration of each sample. The methane concentration scale on the right goes from 0 ppm (dark blue) to a maximum of 1,400 ppm (magenta). With this scale, the orange to magenta range is anomalous. Mean and median values for the methane survey have been skewed by several extremely anomalous samples. The highest methane concentration seen was 9,027 ppm. There are a total of five samples over 2,000 ppm, all extremely high concentrations. Several of the extremely high methane samples were taken in areas with dark, mucky soils. This is probably an indication of biogenic methane from decaying vegetation and not thermogenic methane from a reservoir at depth. For this survey, samples over 175 ppm are anomalous for the area.

The entire northern end of the survey area appears to be mostly blue and green, indicating background conditions. Overall, the clustering of anomalous methane concentrations over the survey area appears to be significant. The trend of the typical Medina field tends to be northeast to southwest and many of these clusters fit this pattern. Areas with no significant production under them typically do not show this clustering effect. Also, the two old dry holes in the survey area are not in an anomalous methane area.

Although it is possible that shallow shale gas is being represented in the methane map, there are several reasons why this should not be the case. The first reason is that overall concentrations are high. Concentrations in excess of 800 ppm are rather unusual. Also, the shale gas would be present at low pressures which would lead to low concentrations at the surface. Additionally, the overall contiguous nature of these clusters appears to be related to more than minor concentrations of shale gas. The anomalous methane concentrations are also similar to the concentrations found over the storage field.

Figure 11. Collins Prospect – Propane Map.

The propane concentration map **(Figure 11.)** is similar to the methane map. Propane anomalies tend to mirror the methane anomalies except in the case of biogenic methane. The propane map will give a truer representation of the thermogenic hydrocarbons as the high biogenic methane concentrations will not have any anomalous ethane, ethene, propane, and heavier hydrocarbons associated with them. The scale on the right runs from 0 ppm for the dark blue to the magenta color which is over 51 ppm. The highest propane concentration was 99 ppm.

The mean of the propane samples was 16 ppm with median at 11 ppm. All samples that are twice the mean are statistically anomalous.

The northern portion of the survey area looks to contain mostly background values. As with the methane maps, a northeast/southwest trend is apparent with an ancillary trend that is northwest/southeast. The old wells are outside of areas higher propane concentrations.

Figure 12. Collins Prospect – Eh Map.

The Eh measured from each sample gives an indication of the reducing conditions in the soil at that location **(Figure 12.)** Areas of actively seeping hydrocarbons will show reducing conditions in the soil represented by low to negative Eh's. The scale to the right runs from a -75 millivolts in the magenta area to a high of 231 millivolts in the dark blue. Hydrocarbon anomalies will be marked by areas of low to negative Eh's shown in magenta and red. The Eh map shown here is essentially a mirror of the hydrocarbon maps. Overall, this map shows reducing conditions marked by low Eh's over the hydrocarbon anomalies. This is to be expected as the oxidation reduction conditions in the soil are directly related to the hydrocarbon breakdown.

Figure 13. Collins Prospect – PH Map.

Figure 13. maps the pH of the soil samples. The scale on the right runs from 4.72 in the magenta to a high of 7 at the top of the scale in the blue range. The pH is used as a reinforcement of the hydrocarbon data. Lower pH's are not only related to seepage but also can be indicative of background values. The pH over the geochemical chimney tends to be only slightly elevated over background. The real differences are along the edges of the chimney where the increased pH tends to be very noticeable. Background in this area appears to be on the order of 4.5 to 5.0. In areas without appreciable hydrocarbon anomalies, the pH escalates up to 6.5 to 7.0. The pH is used more to define the outer edges or the halo of the seeping hydrocarbons. The pH map here shows a somewhat poorer correlation with direct hydrocarbons than the Eh map. The only really high pH's marking the edges of the hydrocarbon anomalies are in the southeast portion of the map and a linear trend in the east-central part of the map. Also, most of the northern portion of the map has somewhat elevated pH's. In this survey, it is possible that there are many numerous large areas of hydrocarbon anomalies so that a classic halo is difficult to ascertain as there is interference from each of these individual clusters of high hydrocarbons. Both the known dry holes appear to be in higher pH regimes possibly indicating background areas.

Figure 14. Collins Prospect – Conductivity Map.

The conductivity map **(Figure 14.)** looks very similar to the pH map. The scale on the right runs from 226 to 754 umhos. The conductivity map again generally shows an inverse relationship to the hydrocarbon data. High hydrocarbon samples tend to have lower conductivities compared to the surrounding areas around the hydrocarbon anomalies. This is related to the fact that greater concentrations of salts, halogens, sulfates and carbonates are formed in this higher pH regime along the edges of the hydrocarbon anomalies. The map shows most of the hydrocarbon anomalies have lower conductivities when compared to the surrounding background areas. This area of high conductivities just to the east of the hydrocarbon anomaly in the northwestern part of the survey appears to be a partial halo. On the north and east of the anomalous hydrocarbon trend also shows a halo. Both dry holes in the area are located within the dark blue areas indicating high conductivities along the outer edges of hydrocarbon anomalies. Once again numerous accumulations within the survey area may be causing interference with each other and a classic halo signature is hard to discern.

Figure 15. Collins Prospect – Stacked Parameters.

The stacked parameter map for the survey is shown as **Figure 15.** The five parameters measured for are methane, propane, Eh, pH, and conductivity. Each of the five parameters measured is assigned a threshold anomalous value. Every sample is then assigned a number according to the number of parameters over the thresholds. The scale on the right runs from 0 to 5 anomalous parameters. Gallagher Labs recommends drilling only on 4 or 5 stacked parameter sites. The map here shows the 4 stacked parameters as red and the 5 stacked parameter sites as magenta. The overall trend of the map matches the hydrocarbon data. Most of the anomalies previously discussed are shown to be 4 or 5 stacked parameter sites. Also seen are the two overall trends to the map as previously discussed.

Figure 16. Collins Prospect – Neutral Network.

Figure 16. is a statistical analysis of the similarity of the samples from the U.S. Energy survey grid to the samples from the known Collins storage field to the southwest. Values range from 0 to 41.5. Values in the blue and green from 0 to 13 indicate very little similarity while those samples with values over 30 indicate very similar conditions when compared to the storage samples. This map closely resembles the hydrocarbon data. Statistically, the most important element seen in the Collins storage field is the high direct hydrocarbon signature over the field. Thus, high hydrocarbons in the U.S. Energy survey grid tend to be statistically very similar to the storage samples.

A southwest to northeast trend is shown in the southern part of the map. This could fit the dominant Medina depositional trend as reworked transgressive barrier bars oriented northeast to southwest parallel to the shoreline. The other dominant but less evident trend is a southeast to northwest trend. This trend looks somewhat weaker than the dominant SW to NE trend. These could be areas of channel sands deposited perpendicular to the shoreline. Also the areas of blue possibly indicate low to no hydrocarbons, which may mark the position of tidal inlets or edges of channels where greater quantities of mud have been deposited leading to the lack of reservoir development.

Recommendations were made to U.S. Energy to drill in areas with the 5 stacked parameters. Their first well in the area (Hofmann Unit #1) was drilled into one of these areas. The geophysical log of the Medina Formation indicated a thin but porous Whirlpool Sandstone section overlain by a thick Grimsby Sandstone section with moderate porosities. Both zones were completed.

This well commenced production in late September and produced 14 MMCF over its' first 6 months of production. This type of production is good for the Medina Formation at this depth. Two new wells were drilled in the prospect area in February 2000. These wells have just commenced production and their potential will be better understood with several months of production information.

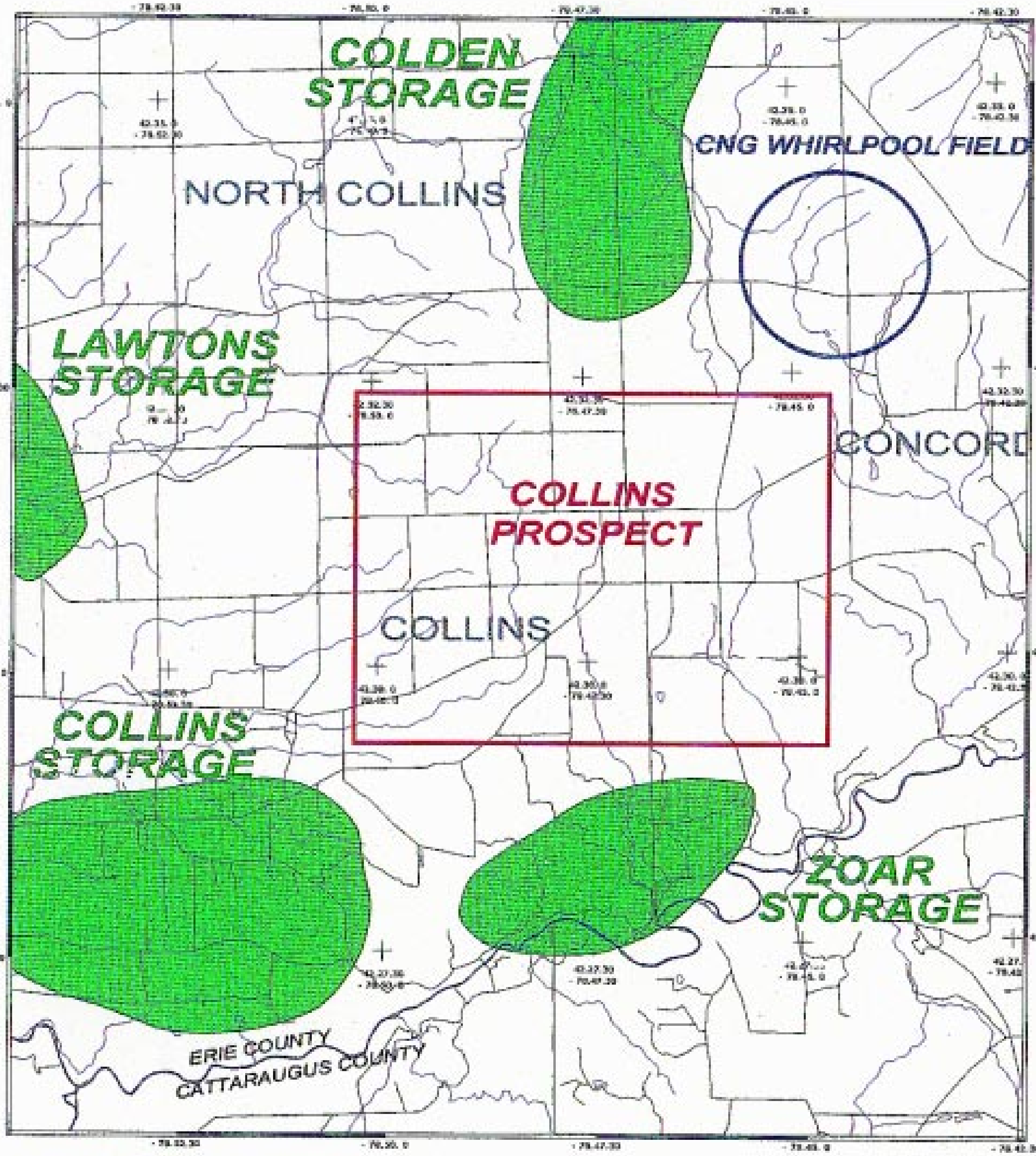
The control (Collins Storage Field) has many similarities to the U.S. Energy Prospect (experiment). Further survey drilling on and especially off the geochemical anomalies will be required to fully understand the potential of this technique to develop Medina Formation.

CONCLUSIONS:

The use of soil gas geochemistry over the U.S. Energy prospect area has proven the existence of substantial soil gas hydrocarbons. Six large areas have been found having substantial clustered hydrocarbon anomalies. These hydrocarbon anomalies have also been confirmed by soil chemistry alterations substantiated by Eh, pH, and conductivity measurements of the soil samples. Examination of the geochemical data from the Collins Medina storage area has proven significant statistical similarities with the U.S. Energy prospect area. Use of the storage field data seems to indicate that the hydrocarbon microseepage found over the U.S. Energy prospect is from the Medina Sandstone and will represent viable drilling targets. The two known old wells in the area were plugged on the basis of no natural shows. Both of these dry holes were drilled in areas seen to have background values based on the geochemical survey. The initial well drilled by U.S. Energy over one of these geochemical anomalies has found a commercial interval of Medina Formation and has produced at this point in time better than average for the Medina. Additional drilling of these geochemical anomalies should definitively prove or disprove the validity of this technique as a method of high grading Medina Formation prospects. Also, drilling off the anomalies may be required to more completely understand their meaning.

At a cost of roughly $8 per leased acre evaluated, geochemistry certainly is much cheaper than drilling or seismic. Of course, every play must be independently evaluated to develop an appropriate exploration methodology. However, geochemistry could be another viable tool for the explorationist to help lessen risk and improve outcome.

Doug/USE
NYSOIL3



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US ENERGY DEVELOPMENT CORP.		
COLLINS PROSPECT REGIONAL LOCATION MAP FIGURE 1		
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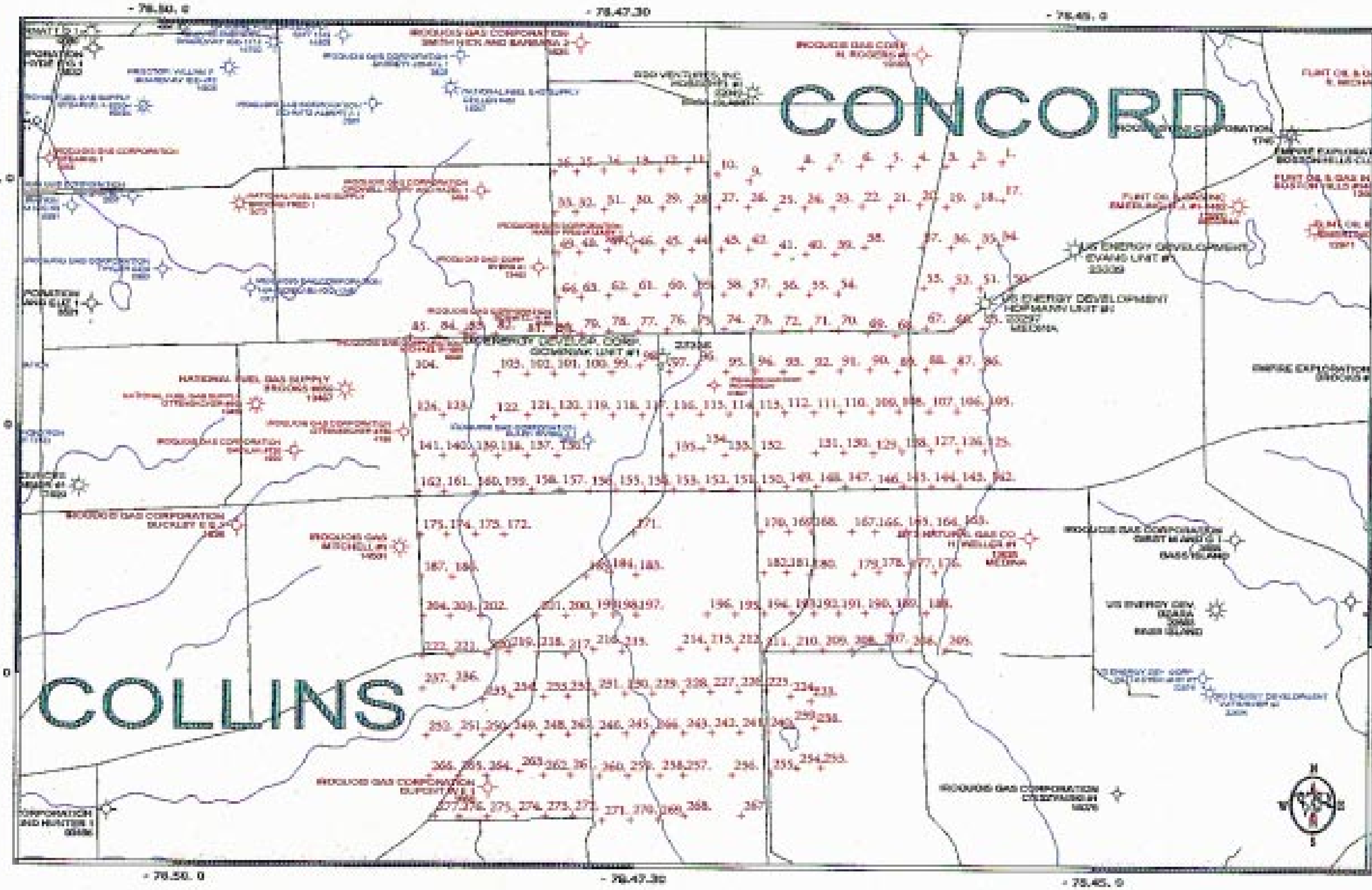

LEGEND

- QUEENSTON T.D.
- QUEENSTON T.D. (CARD DATA)
- QUEENSTON T.D. (LOG DATA)
- BASS ISLAND T.D. (CARD DATA)
- BASS ISLAND T.D.
- GEOCHEMICAL SAMPLE LOCATION

Scale 1:48000.

US ENERGY DEVELOPMENT CORP.		
COLLINS PROSPECT GEOCHEMICAL SAMPLE LOCATIONS FIGURE 2		
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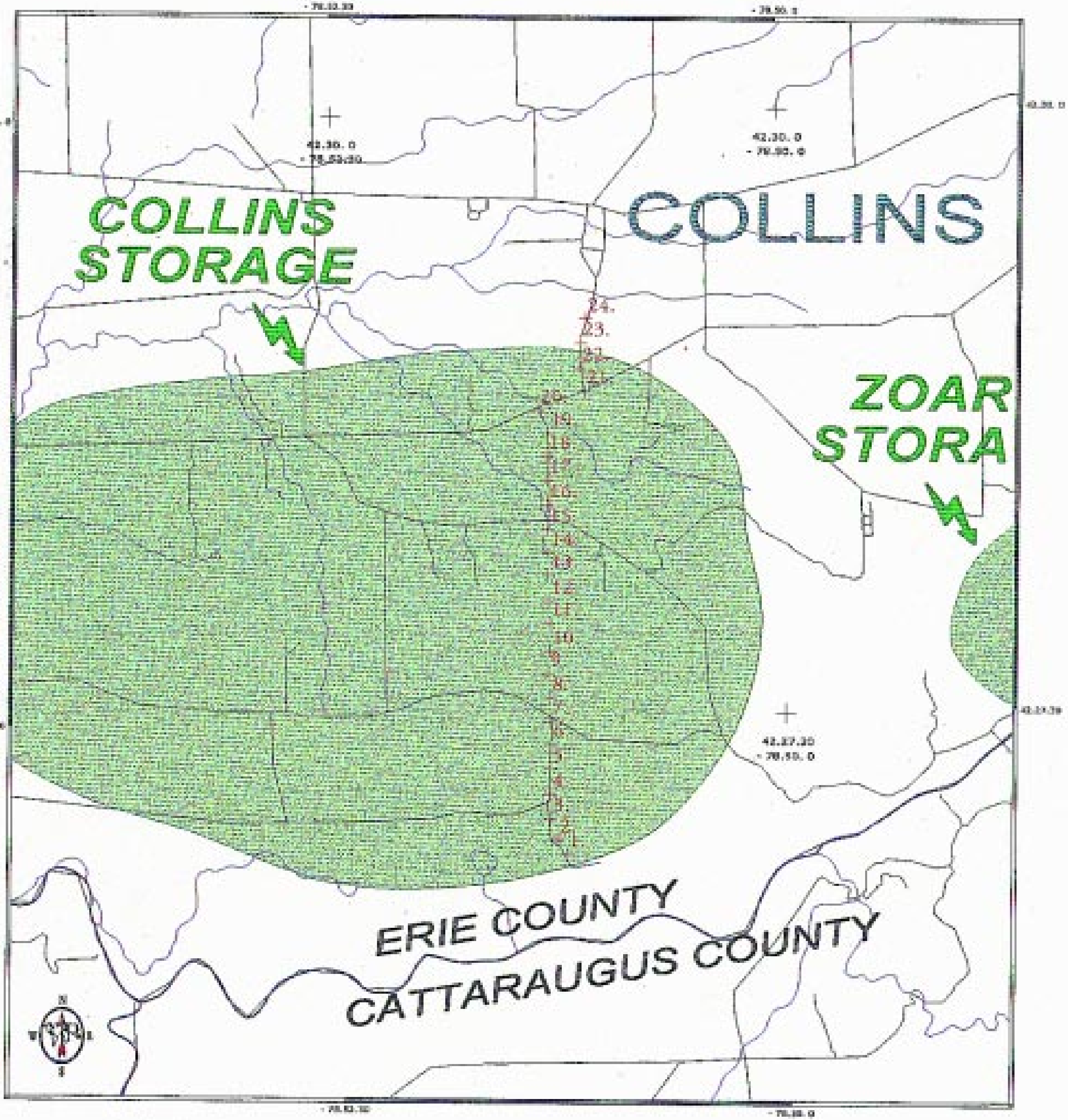
Brian Oakes	Scale 1:48000.	QUEST ENERGY, INC.



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US ENERGY DEVELOPMENT CORP.

COLLINS STORAGE
SOIL GAS SAMPLE LOCATIONS
FIGURE 3

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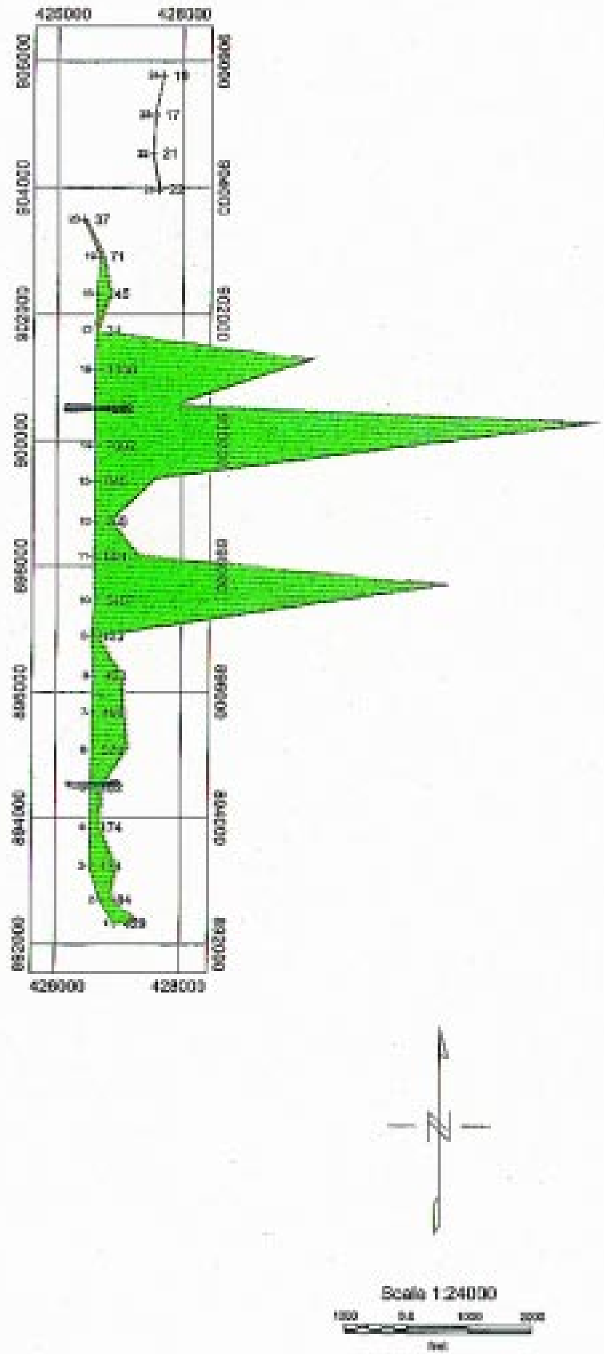

US ENERGY DEVELOPMENT CORPORATION

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Erie County, New York

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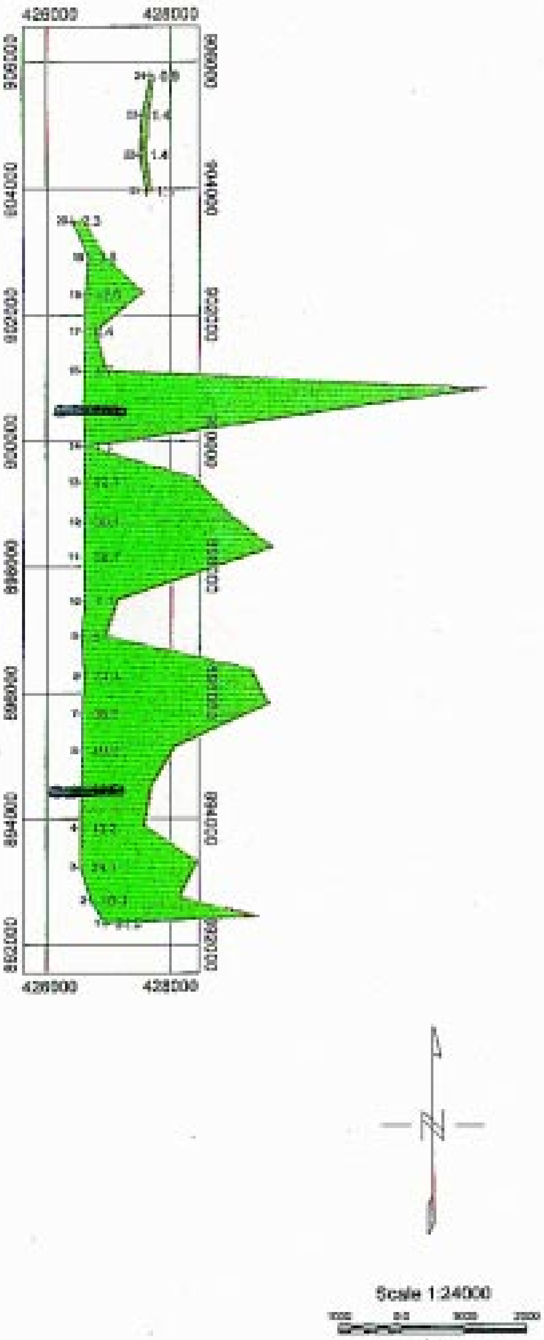
GRDC, Inc.

FIGURE 4



US ENERGY DEVELOPMENT CORPORATION

National Fuel Gas Storage Area
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Erie County, New York

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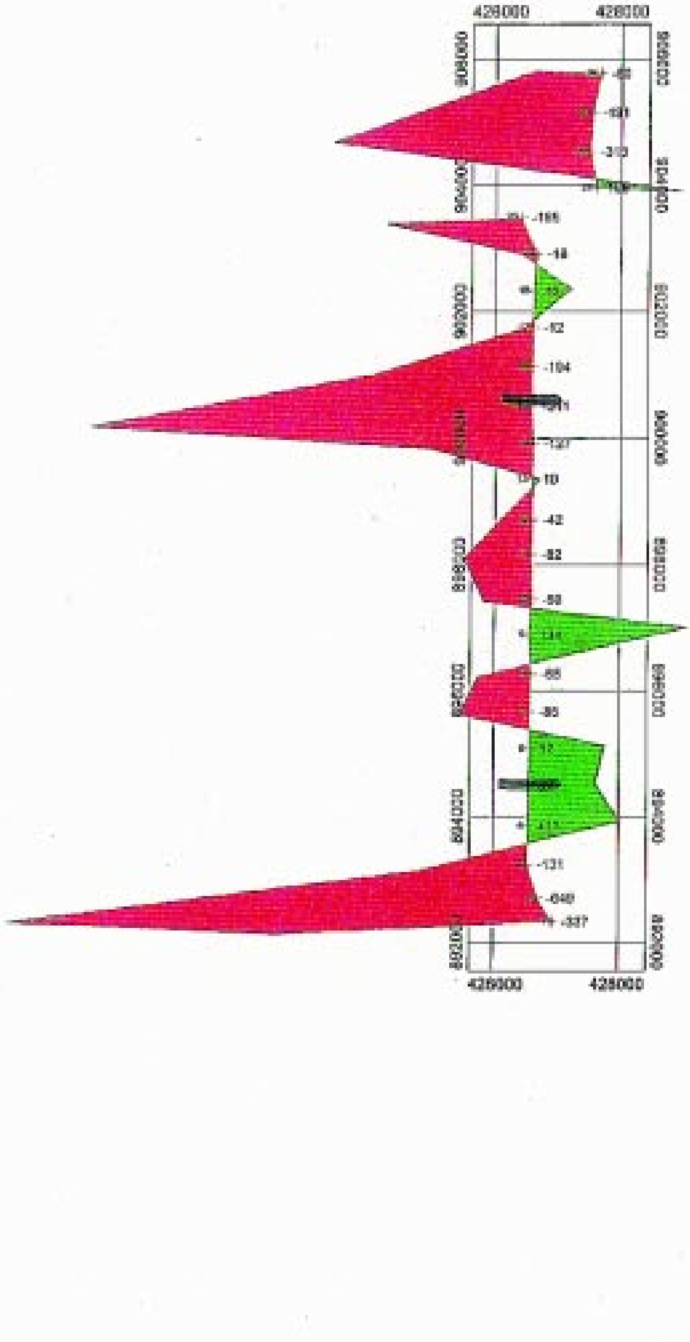
FIGURE 5



US ENERGY DEVELOPMENT CORPORATION
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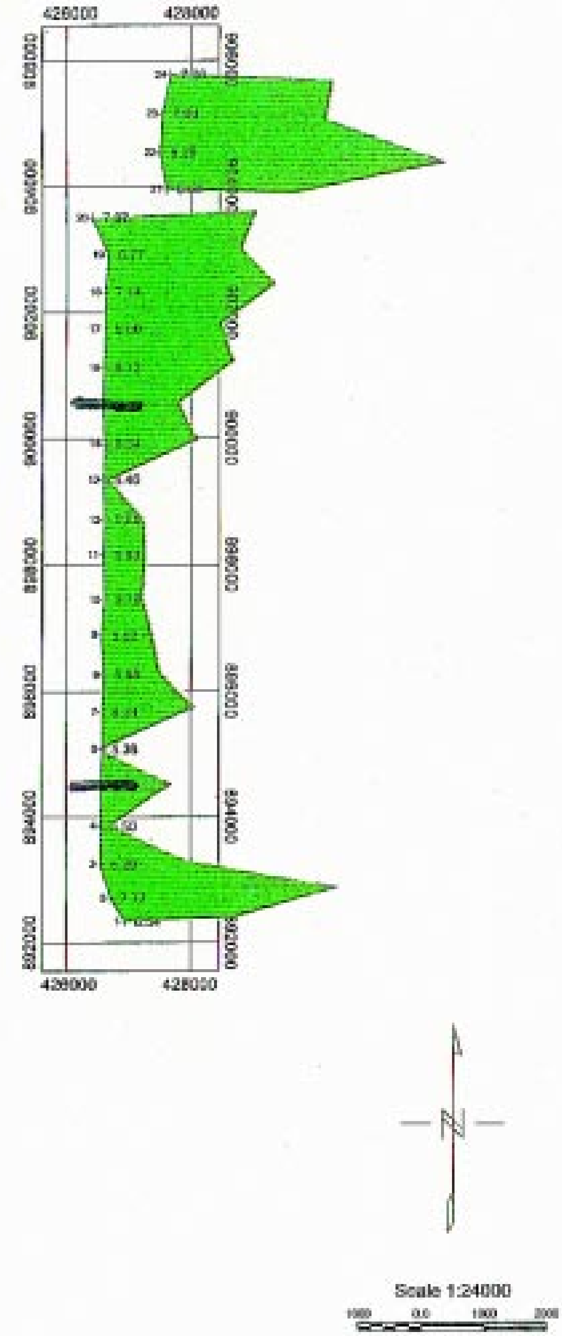
GRDC, Inc.

FIGURE 6



US ENERGY DEVELOPMENT CORPORATION

National Fuel Gas Storage Area
Collins and Concord Townships
Erie County, New York

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GRDC, Inc.

FIGURE 7

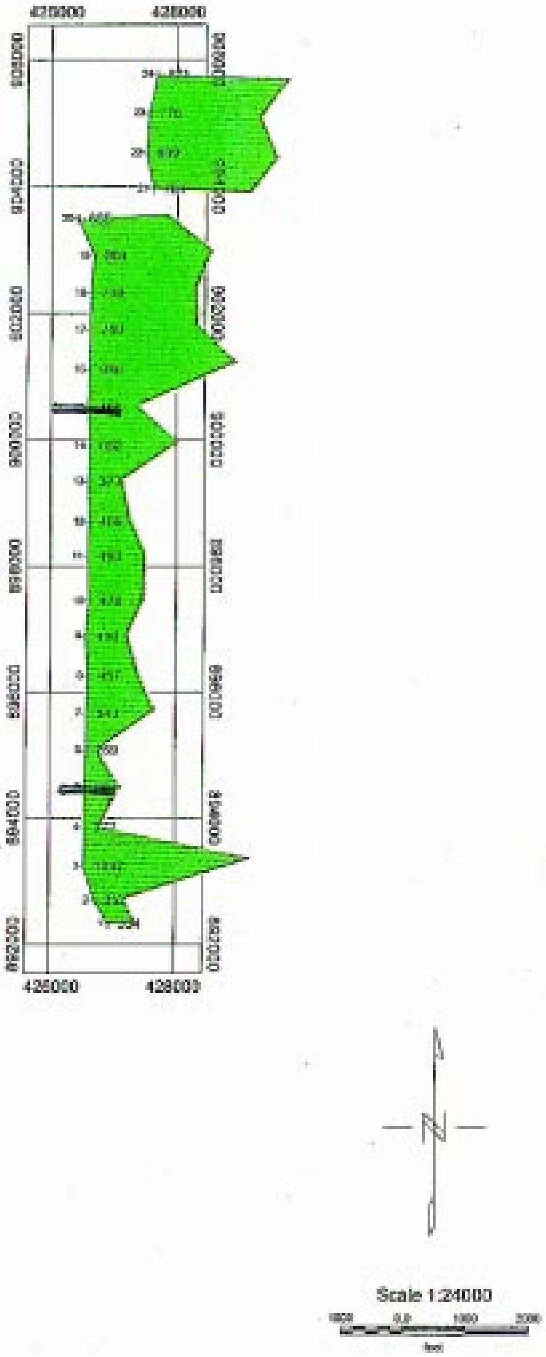

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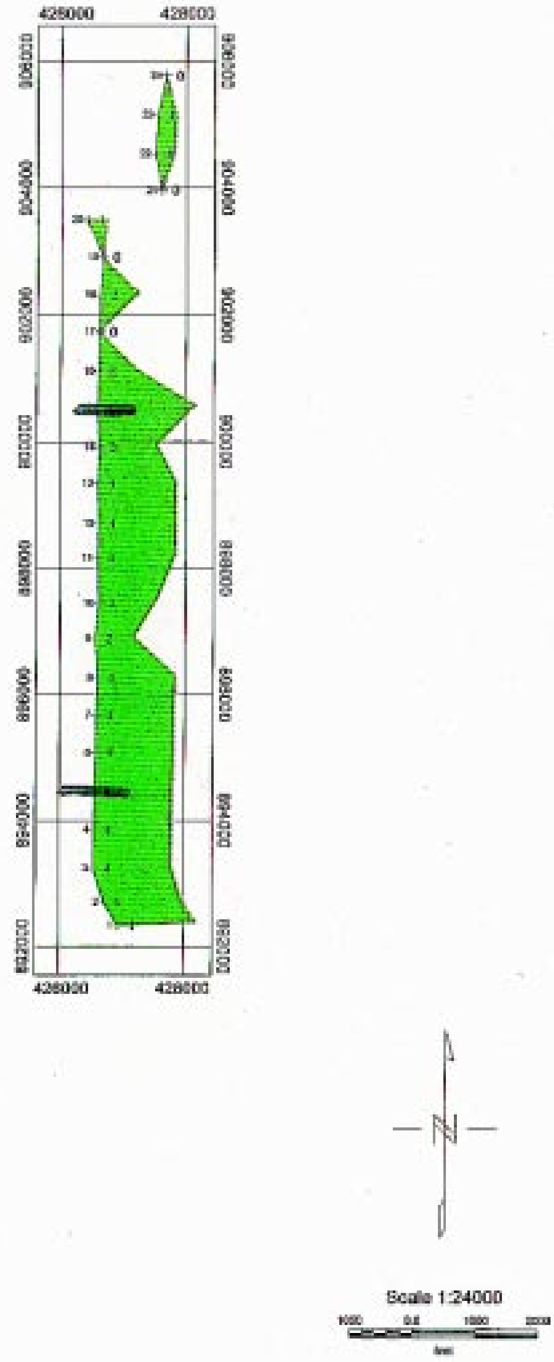
FIGURE 8



US ENERGY DEVELOPMENT CORPORATION

National Fuel Gas Storage Area
Collins and Concord Townships
Erie County, New York

STACKED PARAMETERS
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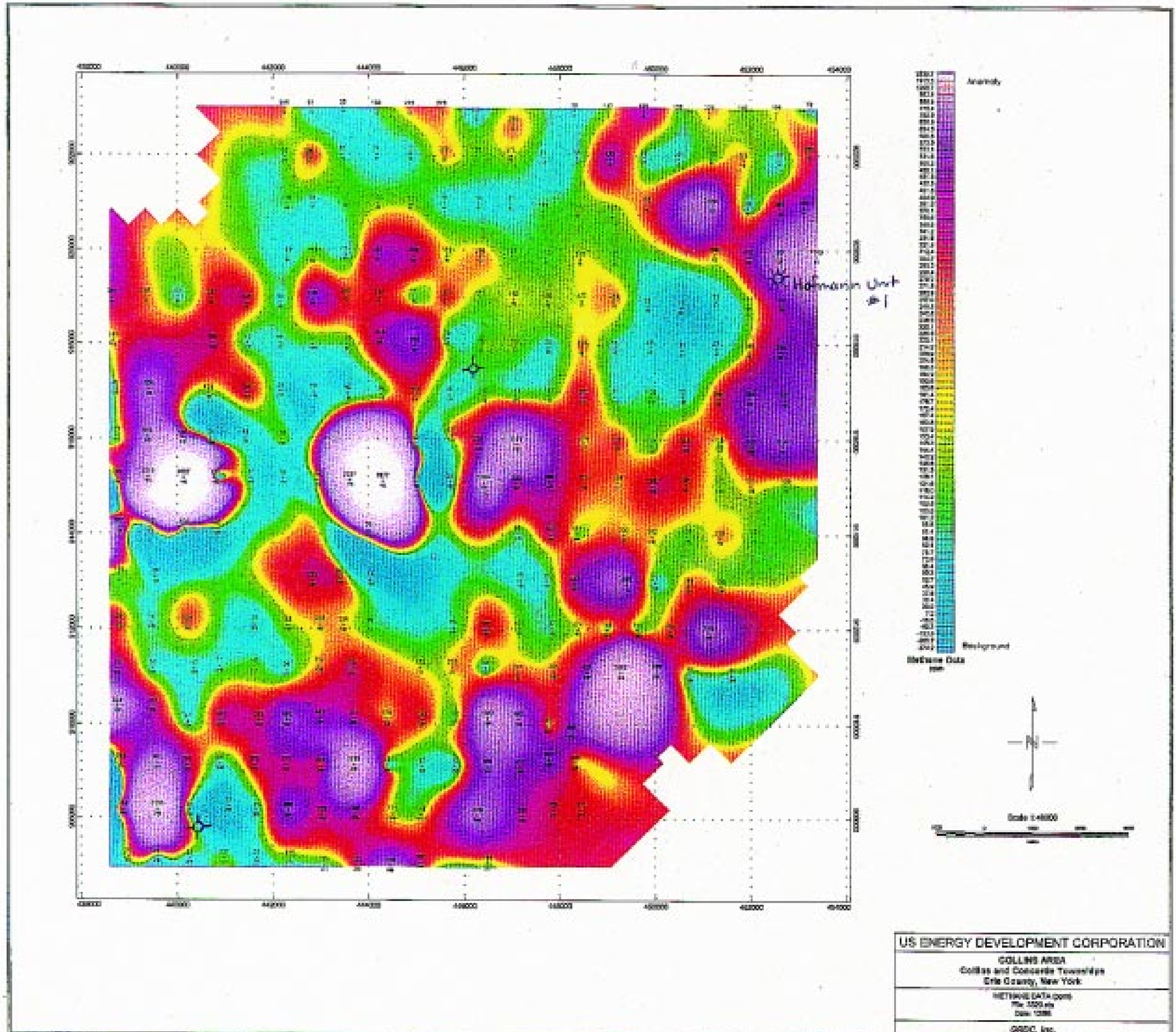
GRDC, Inc.

FIGURE 9


Anomaly
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Methane Data
ppm
Hoffmann Unit #1
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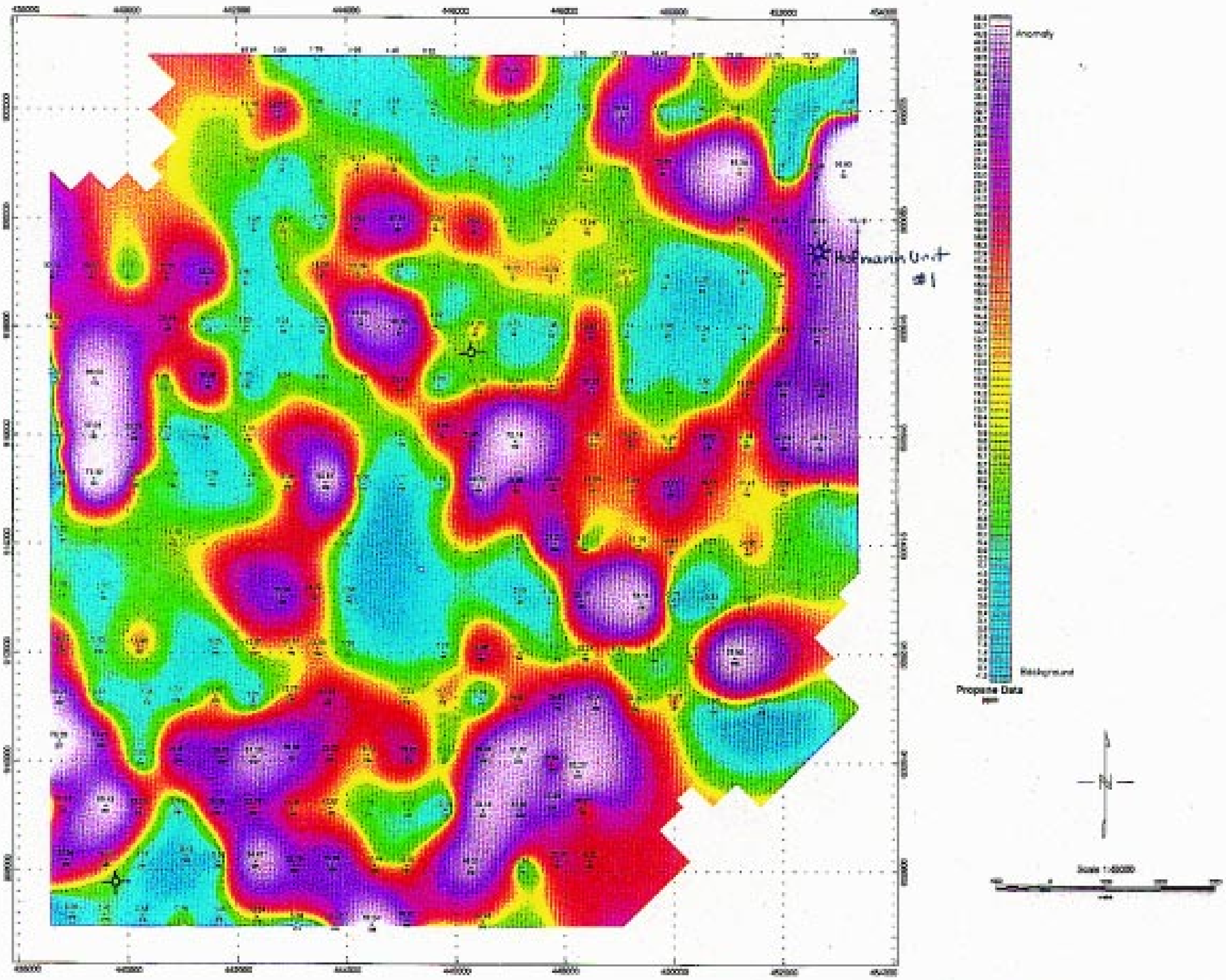
N
US ENERGY DEVELOPMENT CORPORATION
COLLINS AREA
Collins and Concordia Townships
Erie County, New York
METHANE DATA (ppm)
Date: 1996
GRDC, Inc.

FIGURE 10



US ENERGY DEVELOPMENT CORPORATION

COLLINS AREA
Collins and Concord Townships
Erie County, New York

BRDC, Inc.

FIGURE 11

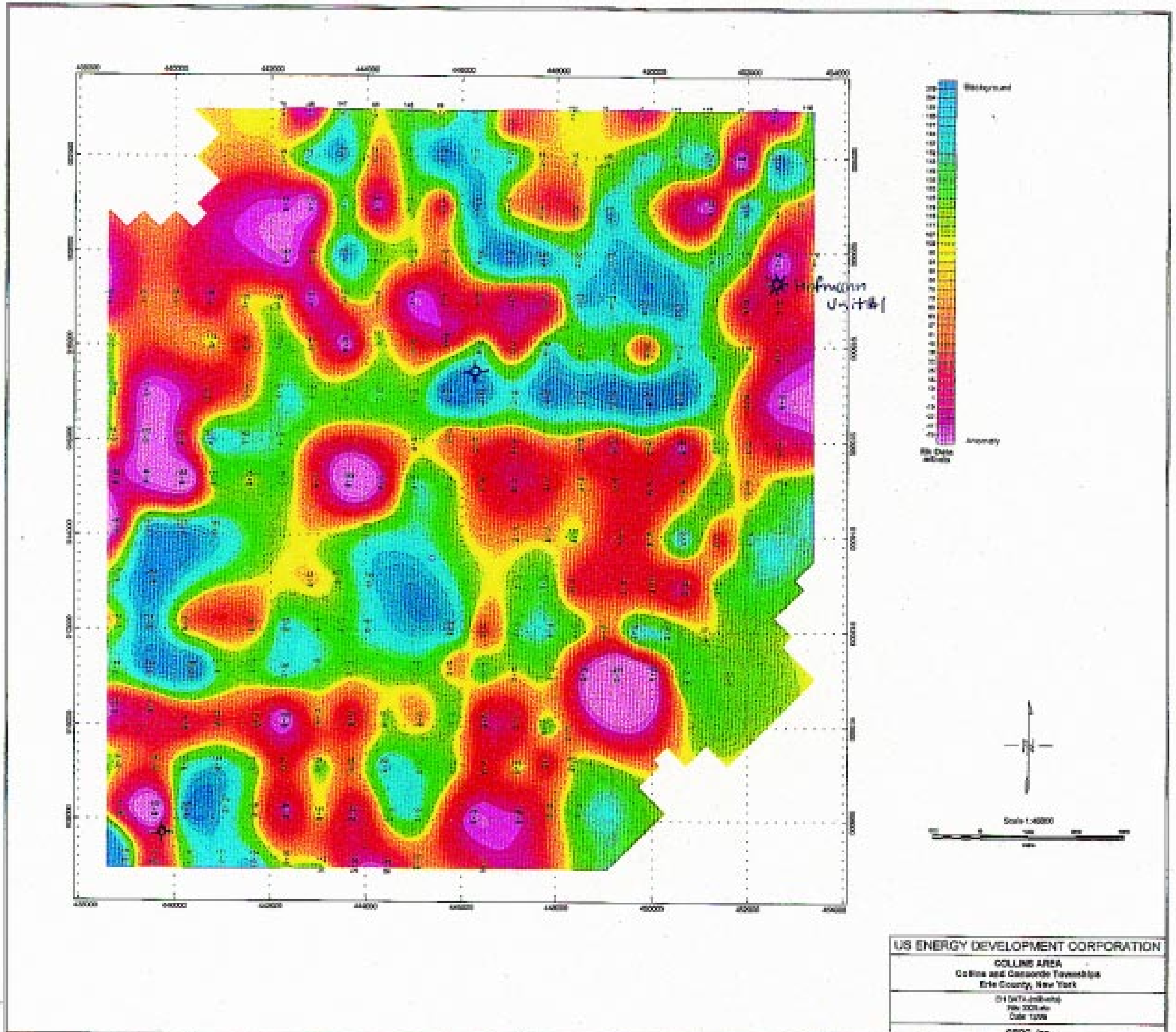
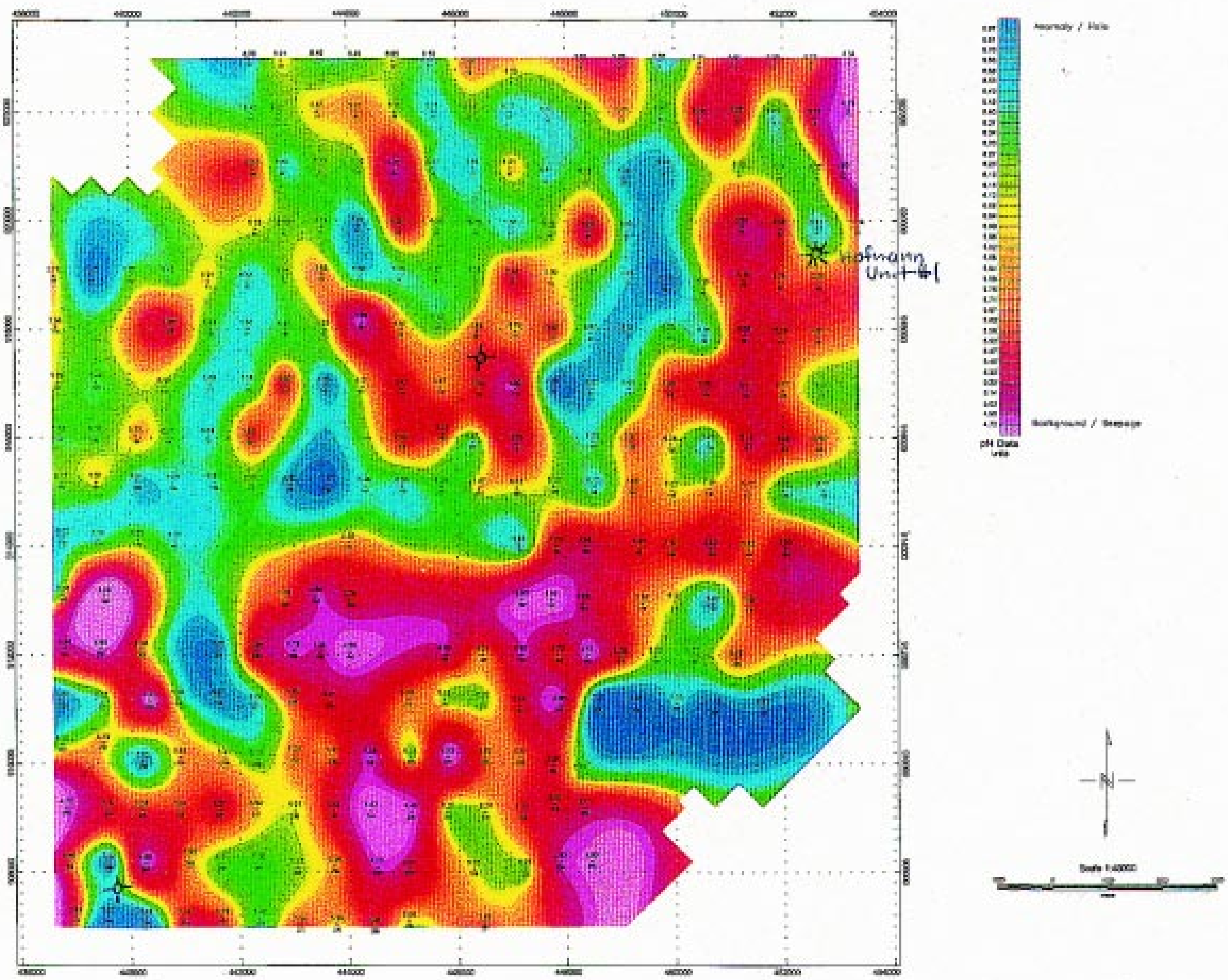

Background
Anomaly
Hofmann Unit #1
Scale 1:48000
US ENERGY DEVELOPMENT CORPORATION
COLLINS AREA
Collins and Concorde Townships
Erie County, New York
GRDC, Inc.

FIGURE 12

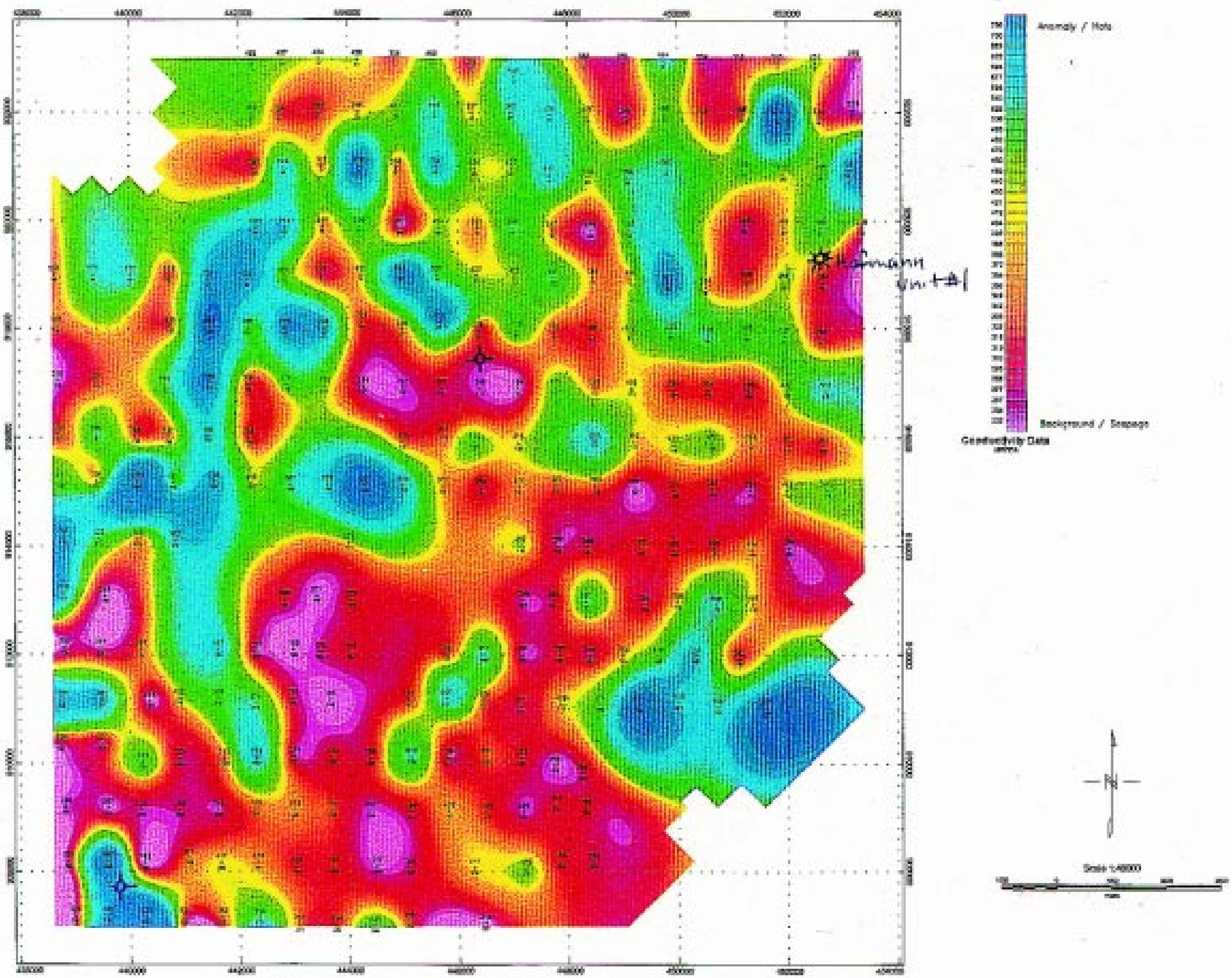


US ENERGY DEVELOPMENT CORPORATION

COLLINS AREA
Collins and Concord Townships
Erie County, New York

GRDC, Inc.

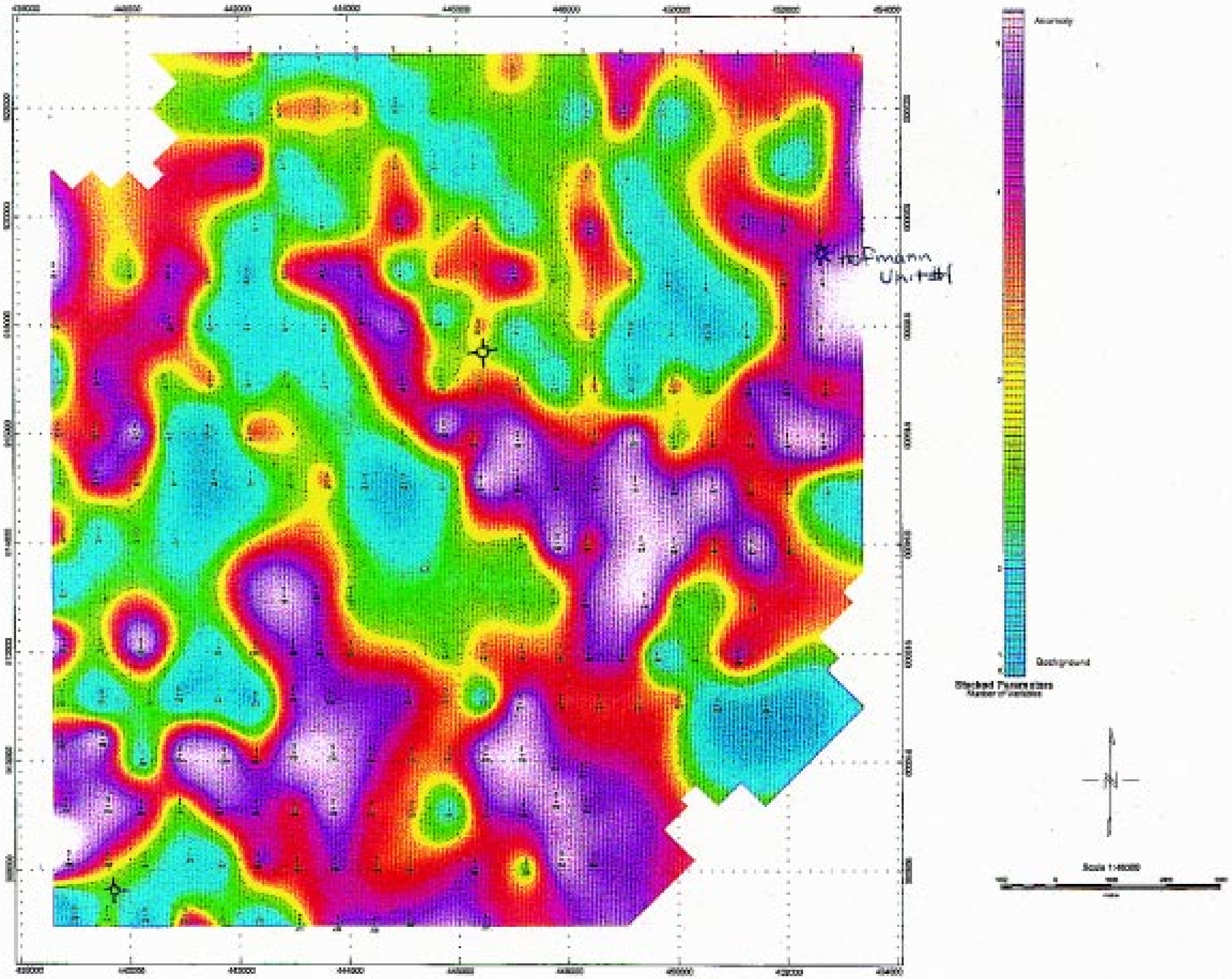
FIGURE 13



US ENERGY DEVELOPMENT CORPORATION

COLLINS AREA
Collins and Concorde Townships
Erie County, New York

FIGURE 14



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COLLINS AREA
Collins and Concorde Townships
Erie County, New York

STACKED PARAMETERS
File: 3305.stc
Date: 12/98

GRDC, Inc.

FIGURE 15

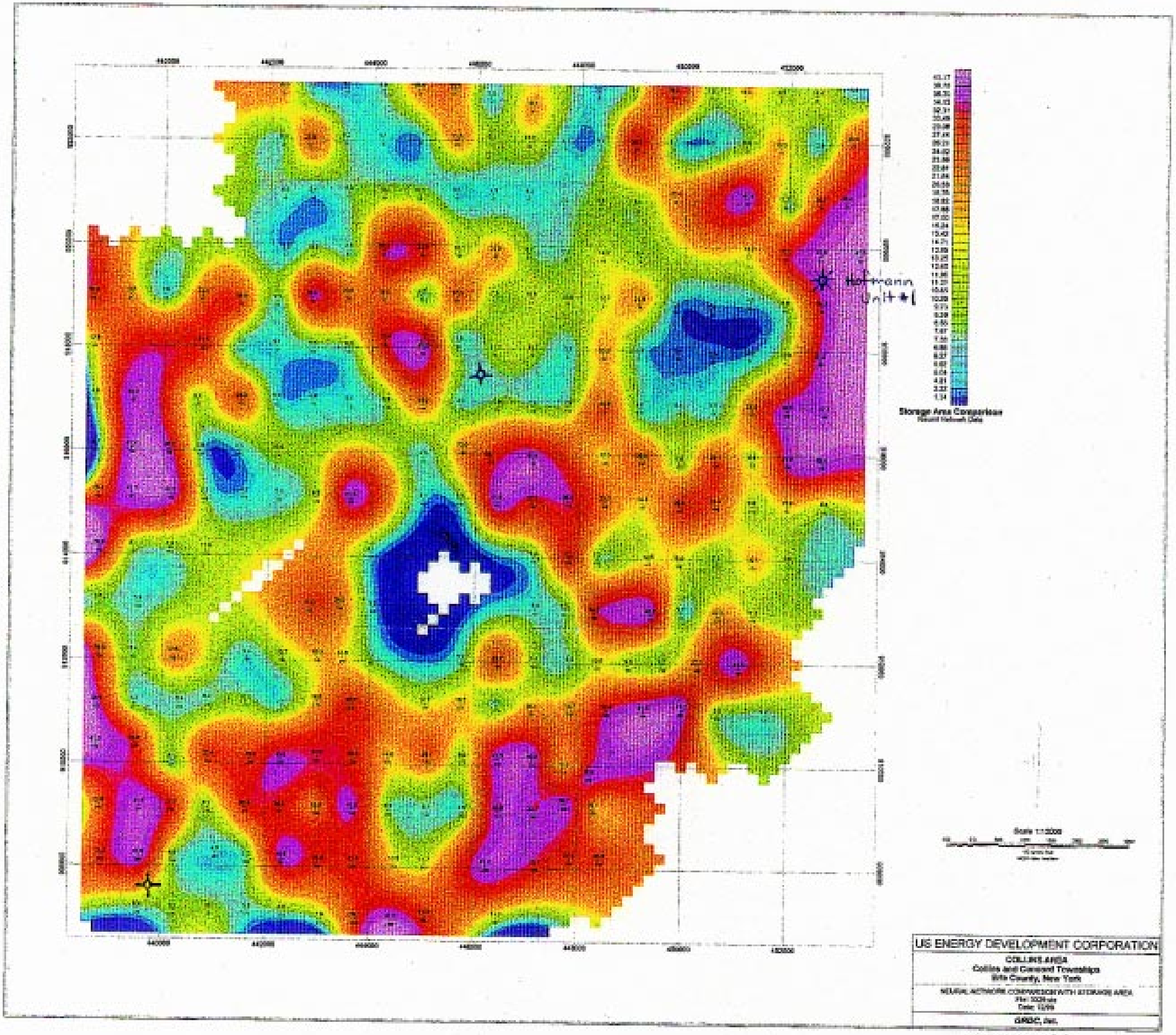
Storage Area Comparison
Hofmann Unit #1
US ENERGY DEVELOPMENT CORPORATION
COLLINS AREA
Collins and Concord Townships
Erie County, New York
GRDC, Inc.

FIGURE 16